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A Practical Background to the Benefits of Spraying versus Spreading Urea Fertiliser on Pasture

Introduction

Nitrogen is frequently the most limiting plant nutrient for pasture growth. Unfortunately, nitrogen fertiliser is energy intensive to produce and is increasingly costly. Also nitrogen is a major source of potential environmental impact from pastoral agriculture through nitrate leaching, nitrous oxide emissions and ammonia volatilization.

This document covers the significant benefits that spraying urea on pasture has over spreading solid urea. This is based on theoretical and research evidence related to the nitrogen cycle and intensive pastoral management.

Suitability of Spraying Nitrogen Fertilizer for New Zealand Pastures

Much of the work on spray application of nitrogen fertilisers has been conducted on horticultural crops but some of the lessons learnt are still relevant for pasture. Fortunately application on to pasture does not have some of the limitations that many horticultural crops have in terms of risk of leaf scorch.

New Zealand is well placed to take advantage of the benefits offered by spraying on nitrogen fertiliser. The predominant form of nitrogen fertiliser for pastures is urea. Urea is extremely soluble in water and is non-ionic. Hanway (1988) described urea as found to be the least toxic and most effective form of N for spray application, is absorbed more rapidly, and is highly mobile in the plants."

Experience with Arable Grains and Pasture

For arable plants and pasture grasses, there is a high tolerance for sprayed on urea. Donaghys experiments have shown impressive responses in pasture dry matter growth related to foliar application of urea. The rate and concentration of nitrogen used in the LessN system has not resulted in leaf scorch though double the concentration and rate (80 kg urea in 200 L of water) has resulted in leaf scorch in one experiment in warm dry conditions.

The Nitrogen Cycle

Much is understood of the way in which sprayed on urea works. There is a rapid uptake of the vast majority of the nitrogen into the plant tissue where it is rapidly converted into ammonium which is in turn rapidly utilized for amino acid and then protein manufacture. The nitrogen is rapidly transported to leaf, stem and crown tissues of the plants.

Soil applied urea follows a very different pathway. There is rapid conversion to ammoniacal form and then a slower conversion to the usually main and more soil-mobile nitrate form. There is typically a lag of a few days before the majority of nitrogen starts being taken up by plants. In the plant, nitrate is converted back into ammonium through an energy intensive reduction process. This reduction process can use a sizeable amount (even 50%) of the plant's available energy from photosynthesis (Whitehead, 2000).

Since urea taken up by the leaf is transformed directly into the ammonium form and is immediately present, spray application of the urea avoids a high energy cost and also avoids a lag in nitrogen being present in the pasture foliage.

Depressing Effect of Nitrogen on White Clover

One of the inefficiencies of solid application of urea is that it can lead to a reduction in the presence of clover in the pasture. The root system of grasses is far superior to that of white clover for the uptake of soil nutrients including nitrogen. Grass outcompeting clover becomes a greater issue as nitrogen inputs are increased and where management of the pasture allows physical overtopping of the clover by the grass.

Even at moderate rates of solid application of urea, there is a reduction in clover nitrogen fixation and clover dry matter. Research has found that applying 100 kg N per hectare reduced nitrogen fixation by 35.5%, and the amount of clover in those swards was reduced by 16.7% by the fertiliser addition.

Much of the reduced nitrogen fixation with nitrogen fertiliser addition is due to lower clover content in the pasture but there is also a temporary but important inhibition of nitrogen fixation in the clover nodules caused by the temporarily high soil nitrogen levels. Prolonged application of nitrogen fertiliser will also tend to reduce infections and resultant nodule formation by Rhizobia in the soil as well as restricting nodule development. Much of this can probably be avoided if application is by spraying on urea with the majority of the nitrogen being taken up directly by the foliage. Clover is a relatively greater ability to take up nitrogen through the foliage than through the roots, thus the spraying is an advantage for clover and it the foliar uptake will likely not have the same feedback mechanism as nitrogen in the soil and roots can have on clover nodules and nitrogen fixation.

Ammonia Volatilisation

Solid urea applied to soil is prone to ammonia volatilization. This is affected by the soil pH, soil aeration, wind speed and temperature (of air and soil). Experiments on spray application of urea has shown that at moderate and even some high levels there is little or negligible ammonia volalisation when applied to pasture Urea on the plant surface is not susceptible to direct ammonia volatilization and it appears that only a very small proportion is converted to ammoniacal form on the outside of the leaf and the urea is in fact rapidly taken into the plant surface. Any appreciable level of ammonia volatilization appears to be related to urea reaching the soil following an excessive application of urea solution. At the rates of urea applied in the Less N system, there is likely to be a very low level of nitrogen that reaches the soil directly.

Nitrates

As described in the Nitrogen Cycle section above, one of the major features of foliar uptake of urea fertiliser is that the nitrate phase is skipped. This represents an advantage where nitrogen fertiliser application through a problem with rate, timing and/or pasture species could otherwise present a risk of high herbage nitrate levels that would compromise animal health.

The nitrate phase in the soil is also skipped by foliar uptake so there is less potential for direct nitrate leaching from the fertiliser application. In most pasture situations, the majority of leached nitrate and denitrification is from the urine patch. The potential impact of spraying on urea on urine patch nitrogen dynamics is discussed below.

In some soils there is a greater risk of a direct impact of fertiliser nitrogen on nitrate leaching and denitrification e.g. free draining sandy or pumice soils, soils with a high water table or with tile drains, and soil that has been routinely receiving high levels of nitrogen fertiliser input.

Denitrification

When nitrate is denitrified to nitrous oxide, this gas can be emitted to the atmosphere. Denitrification can be a significant loss of nitrogen from the nutrient budget and is also a greenhouse gas concern. Spraying urea avoids the nitrate phase in the soil and thus has less potential for direct contribution to denitrification rates. Again, it is the urine patch which is the main concern and this is discussed below.

Urine Patch Effect

The urine patch is a major source of gaseous and leaching losses of nitrogen in a pasture grazing system. Although the urine patch losses will usually eclipse the amount of losses due directly to fertiliser N applications, there can be an indirect effect of fertiliser N application on the level of urine N.

The majority of a moderate spray application of dissolved urea applied to the foliage of pasture grasses is taken up rapidly into the leaves. With the rapid transformation into ammonium form which is directly available for amino acid and protein manufacture, there is no lag in the nitrogen response in plant growth. This means that even if grazing is within two weeks of nitrogen fertiliser application, there has been a full chance for the nitrogen to be utilized in pasture growth and/or transported into the crown of the plant for new leaf and tiller production.

With solid application, it is usually expected that total leaf nitrogen levels are at a peak two to three weeks after application of the fertiliser. In many cases, livestock are coming back in to graze a paddock when the herbage total nitrogen is at its peak. This is before the nitrogen has had sufficient time to promote full pasture growth. It also means that the urinary nitrogen level is going to increase significantly due to the nitrogen fertiliser. The dung nitrogen concentration changes very little but the urine concentration can change markedly.

Studies have found that with increasing fertiliser N input, the nitrogen concentration of the pasture increased significantly but the urine nitrogen excreted in urine even more significantly.

Summary of the Benefits of Spraying Urea

- Spraying Urea means there is no lag time in the nitrogen cycle.
- The plant uptake of N is faster as it is in a more available form.
- Approx. 50% increase in N response when comparing published data and Donaghys trials.
- Plant uptake requires significantly less energy.
- Less energy to convert equals more energy to grow.
- Applying too much Urea can lead to a reduction in clover nitrogen fixation.
- Too much Urea can cause a reduction in the amount of clover present in the pasture due to competition with grasses.
- N losses to the atmosphere by volatilisation are minimal.
- In quick rotation grazing the potential for animal health problems due to nitrate poisoning are greatly reduced.
- Lower N levels in animal's means lower levels in urine and subsequent losses due to leaching.

For a more detailed discussion on the benefits of spraying vs spreading urea fertilizer on pasture and a full list of reference material go to www.lessn.co.nz